Concerted Action for Offshore Wind Energy Deployment (COD): Environmental Issues

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Summary

The Concerted Action for Offshore Wind Energy Deployment (COD) aims to progress offshore wind energy in the EU by gathering and analyzing the present state of knowledge on environmental issues. COD has generated a database[1] which contains published studies and information about the effects of offshore wind facilities on the marine environment in the participating countries. The publications were analyzed putting a focus on the results of monitoring and effects studies concerning main impacts resp. main cause-and-effect-chains.
In addition, also the role of plannig instruments such as Environmental Impact Assessment (EIA), Strategic Environmental Assessment (SEA) and spatial planning instruments were considered.

Observations

On the national scale, the paticipating countries have chosen different approaches to investigate both preconditions and effects of offshore facilities on the marine environment.

- **Denmark** is gaining very valuable information on actual effects on the marine environment. Investigation and monitoring the effects of already built projects is part of a demonstration programme covering the wind farms Nysted and Horns Rev. This programme, including monitoring, is still ongoing and will be running until 2006. Thus, more results can be expected in the years to come.
- **Germany** on the other hand performs a basic environmental investigation programme, publicly funded within the framework on offshore wind energy research. At present, results are available from the phase of precursory research, which was accompanying the offshore wind development strategy in Germany. To gain project-related information, effect studies and monitoring studies are carried out on a research platform (FINO I). Two more platforms are planned in the near future. A co-operation between Germany and Denmark is being prepared in the framework of the 'Joint Declaration on Environmental Research'. As no offshore wind projects have been realized up to now, results from project-related monitoring studies are not available.
- In the **Netherlands**, two project-related impact assessments have been performed; up to now, no projects have been built so far. A potentially suitable area is presently undergoing baseline studies on defined components of the environment.
- In the **United Kindom** the information on environmental issues is mainly concentrated in project related impact studies. In the United Kingdom - and also in **Sweden** - further research projects focus on the areas designed as suitable for offshore wind exploitation.

Offshore wind exploitation is a new type of marine use, whose effects were widely unknown. Offshore wind deployment is now obviously considered as an opportunity to improve both the informational basis on the marine environment and the knowledge about the impacts. Not all data gathered on the occasion of planning an offshore facility are necessarily required to

[1] COD database: http://www.offshorewindenergy.org. The reference numbers (e.g. COD-DK-01) refer to the record numbers in the database.

take a decision on the licensing. They also help to achieve the best available precaution measures during construction and operation.

- Based on EIA-regulations the scope of subjects to be investigated are similar in each country. Nevertheless, the depth and duration of investigation of the single subjects for Environmental Impact Studies (EISes) differ due to the specific legal consenting requirements.
- Up to now, knowledge on environmental effects is still mainly based on single case results. Generalizing of results is restricted due to the large site specific differences (e.g. differences due to location in North Sea or Baltic Sea; water depth, structure of sea bed, location to the coast; occurrence of endangered species). In many countries guidelines on investigation requirements have been issued to standardize methods and assessment approaches. Compiling the required environmental data and assessments does not seem to be a major constraint to getting a licence for offshore projects any more.
- Fulfilling the **precautionary principle** (i.e. by assuming worst-case scenarios) investigations of effects on the marine environment may be more comprehensive than is necessary for licensing. In most cases this is tolerated by commercial developers as they are eager to underline the positive environmental effects of offshore wind.
- In some of the countries (e.g. United Kingdom, Germany, Sweden) a scheme of **pre-selected** (preferred or suitable) **areas** has been developed. To select sites, approaches of **Strategic Environmental Assessments (SEA)** have been applied.
- The development of criteria and standards for evaluation of impacts is still at the beginning. Results of evaluation differ dependent on the prevailing protection aims or development aims. Validation of criteria still needs more research on the causal interferences of the marine environment and offshore wind facilities.

Conclusions

- Knowledge on factual effects of offshore wind is still limited and widely based on assumptions. This is partly due to constraints regarding the predictability of effects under natural conditions. Nevertheless, even in view of prognostic uncertainties decisions have to be taken.
- In view of knowledge gaps it has to be discussed in which way the basis of decision making in EIA and consenting procedures could be improved and qualified in the most effective way.
- Cumulative effects and follow-up effects appear to bea major problem. As yet, common methodology or tools to address cumulative impacts are still missing.
- Exchange of knowledge and information on environmental information has sucessfully been started. The need for transnational approaches seems to be obvious.

Recommendations

- Progress in knowledge can best be achieved by implementing more offshore wind farms as pilot projects, being submitted to monitoring the effects. This appears to be the only way to also gain knowledge on large scale effects and potential cumulative effects.
- Delineation of suitable areas for offshore wind deployment and Strategic Environmental Assessments, which allow the consideration of cumulative effects, are helpful planning instruments, which provide planning reliability for intending developers.
- Viewing the prevailing occurrence of cumulative effects and large-scale effects it is a promising approach to pursue a strategy of delineation of suitable areas resp. protected areas.
- Research should focus on the supply of survey data at the scale of Strategic Environmental Assessment.
- To improve the comparability of results, competent authorities should harmonize standards for project related investigations in EIS and monitoring obligations (duration, number of reference sites, method and frequency of baseline investigations).
- The development of evaluation standards should be enforced on national and international level.
- The compilation and exchange of knowledge should be systematically continued in the future.

1 COD's compilation and analysis of environmental issues

1.1 Introduction

In order to fulfil the legal requirements for licensing, developers of offshore wind farms are obliged by national authorities to undertake project-related environmental baseline surveys and monitoring studies and/or to undergo Environmental Impact Assessments. Since offshore wind is a relatively new activity, developers often face knowledge gaps as well on the state of the concerned marine environment, as on the actual effects wind turbines will emit during construction and operation phases. However, the major question turns out to be the evaluation whether these effects lead to negative impacts on the marine environment, and which significance these impacts will have.

1.2 The Scope of environmental issues

Environmental issues cover not only the effects of offshore wind facilities or it's impacts on the the marine environment, but also include tools for environmental planning and assessement.
To facilitate international exchange of information and thus support responsible deployment of offshore wind in Europe, one aim of COD was to collect existing publications and give access to existing knowledge on environmental issues of offshore wind in the participating countries. Titles and information (key words) were gathered in a database and made accessible on the COD-website (see: http://www.offshorewindenergy.org/index_cod.php).
The COD project set a focus on a scope of environmental key issues[2]:

1. **Components of the marine ecosystem:** birds (seabirds, resting birds, migrating birds), marine mammals, benthos, fish, soil/seabed, hydrology and visual landscape and men. These "receptors" of the generated effects are regularly investigated in EISes.
   This widely agreed spectre of components of the marine environment is derived from national EIA-regulations and guidances on offshore wind facilities. The investigation and evaluation, especially the assessment of the named components differ in the degree of being operable in assessment procedures.
   Whereas the *spectre* of subjects is widely agreed, there are different opinions on the relevance of singular components (e.g. effects on benthos communities) for decision making. One reason for this is that impacts on those components are considered presumably low. It has to be stated that the significance is a result of an evaluation process - so criteria must be named when discussing about the significance.
2. **Relevant effects or influencing factors** which are exerted on the environment are e.g. noise/vibrations, loss of habitats in consequence of disturbance and avoidance, collision risks, electromagnetic fields, introduction of hard substrates (especially in soft bottom areas), sedimentation/turbidity and visual intrusion.[3]
   In the COD-report on Environmental Issues besides mentioning main effects or impacts, the main cause-and-effect-chains are summarized. The definition of **cause-and-effect-chains** exceeds the mere listing of effects (pressures) or potentially inflicted 'receptors'. They are an important step towards **standardization** of EIAs for offshore wind projects.
3. The performance of Environmental Impact Assessments (EIA) and planning procedures was also a focal point in COD's attention Methods and requirements for Environmental Impact Studies (EISes) are closely related to the correspondent national regulations. Approaches of spatial planning or other approaches of site selection (including the designation of marine protected areas and the selection of suitable areas for wind farms)

[2] See IEA R&D Wind (2002): 40th IEA Topical Expert Meeting – Environmental Issues of Offshore Wind Farms. Husum/Germany, September 2002; OSPAR COMMISSION (2004): Problems and Benefits Associated with the Development of Offshore Wind Farms; p. 8-9.

[3] See OSPAR COMMISSION (2004): Problems and Benefits Associated with the Development of Offshore Wind Farms; p. 10.

play an important role. They improve the reliability of project plannings. Strategic Environmental Assessment (SEA) is presently gaining more importance in assessment procedures on superior planning levels.

4. The subject of **avoidance and mitigation measures** was looked at from two angles: firstly trying to identify the potential means and measures for avoidance and mitigation; secondly evaluating the proposed measures, i.e. if and under which circumstances they are practicable and helpful.
   However, experiences on mitigation (with the aim of compensation resp. re-establishing impacted issues) could not yet be reported on.

1.3 COD database on environmental issues

To facilitate an overview on what is considered as the major activities concerning investigation, assessment and research in each country, as well as on the major results of surveys, effect studies and monitoring an **Access-database** was developed[4]. It supports a structured compilation of information. This database was last updated in July 2005 and has since been available on the COD-website.

1.3.1 Content of the COD database

The COD-database contains at present more than **280 entries**[5], provided from Belgium, Denmark, Germany, Ireland, the Netherlands, Poland, Sweden and United Kingdom.
Different types of publications and studies are recorded in the database, for example:

- studies / statements on Environmental Impact Assessments,
- studies on planning and assessment instruments (e.g. EIA, SEA),
- studies and reports regarding research projects (e.g. generic R&D, project-related monitoring studies),
- published guidelines / terms of reference (e.g. for ecological examinations or for EIA proceedings),
- programmes / strategy papers e.g. by national governments,
- conference reports.

Most of the recorded reports come from Denmark (due to the extensive environmental monitoring programme at the wind farms Horns Rev and Nysted), followed by the United Kingdom and Germany (cf. table 1). It should be noted, that interpretations of the amount of data records must be handled with care, as the database is not claiming to be complete.

Table 1: Data records on environmental issues per country

Country	**Amount of data records (∑ 284)**
BE (Belgium)	9
D (Germany)	56
DK (Denmark)	119
IRL (Ireland)	5
NL (Netherlands)	19
PL (Poland)	1
SE (Sweden)	6
UK (United Kingdom)	69

[4] The Access database was designed by New-Energy-Works (Utrecht/The Netherlands) in 2003.

[5] The database entries are also available listed in a table, indicating title, year of publication and editing institutions (see 'Report on Environmental Issues, annex I 'Comment on the database').

Quite a number of **generic research projects** and **project-related monitoring studies** are still in progress (see e.g. ongoing projects in Denmark and Germany). Much more publications are expected until the end of 2006/2007. To keep the database a valuable information tool, it is of great importance to go on with accomplishing and actualization of entries and results.

1.3.2 Information on investigation and evaluation methods

The gathered publications refer mainly to investigation methods in connection with baseline and monitoring studies regarding specific marine biota (e.g. marine mammals, seabirds, fish). They describe which methods have been or should be applied for the surveys.

Concerning investigation methods for **birds**, the 'Best Practice Guidance for the Use of Remote Techniques for Observing Bird Behaviour in Relation to Offshore Windfarms" (COD-UK-053) gives the most comprehensive recommendations on which methods best meet the requirements.

Concerning **marine mammals,** possibilities and constraints of the use of porpoise detectors (POD), telemetry (satellite tracking) and aerial surveys and ship-based surveys are studied best in Danish effect studies. To answer the questions posed, in most cases a combination of methods is recommended.

The database also contains some publications, *solely* referring to investigation and evaluation methods. These are mostly **guidances** which describe thematic, technical and/or methodological requirements for environmental investigations and evaluations/assessments. The following mentioned database-entries highlight some examples:

- COD-D-001 (Investigation-Standards for Environmental Impact Assessments...)
- COD-UK-006 (Guidance for ... Seascape Assessment);
- COD-UK-018 (Environmental Impact Assessment in respect of FEPA and CPA Requirements)
- COD-NL-003 (Terms of reference, procurement base line studies North Sea Wind)

1.3.3 Information on Environmental Impact Assessment

Most of the provided publications which refer to environmental assessment are **Environmental Impact Studies** (EIS) for specific wind farm projects. Regarding the total number of recorded EISes (see COD-report on legal and administrative issues) one can assume that meanwhile there is good practical experience in how to perform an impact assessment. In view of the relevance of *cumulative* effects it is important to mention that assessments must also be carried out on a larger scale.

The database contains very few reports dealing with environmental assessment and planning *procedures* in principle (e.g. methods of prognosis and evaluation, standards or criterions for the assessment of the significance of expected impacts).

- In Germany some research projects are concerned with the 'best practice approaches' for environmental assessment instruments like SEA, EIA and Habitats Assessment (see e.g. COD-D-006, COD-D-028, COD-D-031).
- In the United Kingdom some of the publications provide guidances (see e.g. COD-UK-018, COD-UK-044), but also report on specific assessments like the carried out SEA for offshore wind energy (see COD-UK-017, COD-UK-048).

1.3.4 Information on Strategic Environmental Assessment (SEA) and spatial planning

Strategic Environmental Assessment (SEA) would be an appropriate instrument to assess cumulative effects on a superior planning and decision making level. Formal application of SEA on offshore wind requires offshore wind exploitation to be subject of an *official plan or program*. If this is not the case, SEA-like strategies in context of spatial planning will be an appropriate approach to assess cumulative effects. Approaches should be developed to also allow transboundary approaches.

Information on procedures and applied methodology concerning SEA are still few in number, as the implementation of SEA on national level is just beginning.

Apart from some German reports, the database containes only little information on general aspects of **spatial planning** at sea, like the designation of marine protected areas (e.g.Natura 2000-sites, Special Protection Areas -SPAs) and the selection of suitable areas for wind farms (see e.g. COD-D-017, COD-NL-019).
Spatial planning applied in territorial waters is an effective tool to manage the patterns of marine uses and diminish conflicts between the different marine uses in these areas. Apart from spatial planning, nearshore wind farms sites should also be an issue in integrated coastal zone management (ICZM[6]) strategies. However, there is hardly any information concerning the implementation of a comprehensive marine spatial planning (see e.g. COD-D-042).

1.3.5 Information on avoidance and mitigation measures

Proposals on how to avoid or mitigate the adverse effects of the construction and operation of wind farms are usually contained in the project-related EIS.

Two German publications and projects (see COD-D-007, COD-D-008) focus primarily on technical avoidance measures to minimize risks of ship collision. Besides, also some generic research projects refer to avoidance and mitigation measures mostly in connection with selected marine biota (e.g. birds, marine mammals).

Studies on negative impacts due to grid connection (COD-D-007) also contain proposals to reduce the follow-up effects, e.g. by bundeling the cable routes. Avoidance of impacts by grid connection is an important issue, especially if - as in Germany - the coastal zone is a protected area (national park).

2 Impacts on marine wildlife

2.1 Marine Mammals

The following table gives an overview on the **adverse effects** on marine mammals by mentioning the **main** impact correlations and pressures[7] due to offshore wind farms:

Table 2: Offshore Wind-related Impact Correlations regarding Marine Mammals

Impact Correlations	CODs preliminary results
Physiological damage leading to direct and indirect loss of individuals (e.g. acute hearing damage due to ramming or pile-driving noise).	Yet, no case of direct loss of individuals was documented. Impacts of noise and vibration (i.e. during construction) on the mortality or birth rate of marine mammals have not yet been studied.
Temporary reduction of habitat size and displacement of species due to construction and maintenance activities.	Monitoring results at Danish Horns Rev Wind farm confirm that during the construction phase seals and cetaceans avoid the area. Supposed reactions that for instance curiosity might attract seals and cetaceans to the building site, could not be stated. In all sites known as sites frequented by seals or cetaceans, impacts arising from boat movements and the installation of piles have to be assessed.

[6] See http://europa.eu.int/comm/environment/iczm/

[7] See TU Berlin & Bundesamt für Naturschutz (2005).

Impact Correlations	CODs preliminary results
Permanent reduction of habitat size due to operational noise emissions from the wind farm and other activities.	To which extent wind farms lead to a diminution of suitable habitats is still being discussed. There are observations that marine mammals avoid wind farm areas whereas others observe that after construction marine mammals do not show any change in behaviour. It is still in question whether disturbance by follow-up effects like boat traffic (tourism, maintenance) will have significant long-term effects.
Disturbance of intra-species communications (e.g. masking of communication).	Noise emissions are expected to be at lower frequencies than those used by dolphins and porpoises for echolocation to hunt prey, so they should not be affected.
Barrier effects for migrating animals due to noise emissions during the operational phase, or to electro-magnetic fields.	It is widely agreed that no significant barrier effects for migrating animals are known to date.

According to preliminary results of Danish monitoring studies, the mentioned impact correlations cause less negative impacts on marine mammals than was expected.
However, due to knowledge gaps and viewing the strains caused by other uses, the precautionary principle should nevertheless be applied to protect endangered populations of mammals:

- Avoidance of "hot spots" like densely populated areas or sanctuaries to reduce potential risks to a minimum;
- Appliance of mitigation measures, i.e. reduce noise emissions, avoiding sensitive life cycles, repelling of mammals during construction phase;
- Reduction or limitation of boat traffic.

2.2 Birds

Birds are subdivided into two groups with similar habitat requirements and behaviour: **seabirds resp. resting birds** as one group and **migrating birds** as the other.
Meanwhile there are methodological guidelines which could ensure that comparable methods are applied when surveys are performed. However, possibilities of generalization are restricted, as birds' reactions depend on various factors: species, behaviour, location, season, weather conditions, natural factors like food supply etc. Thus, the interpretation and generalisation of effect study results is very restricted, too. The most informative results dealing with the reaction of birds on wind turbines are provided by the Danish demonstration programme.
A notable number of baseline studies and surveys on abundance has been carried out, but the information base on bird stocks and their patterns of occurrence still need improvement. Also the interpretation of the results has to be continued.

Table 3: Offshore Wind-related Impact Correlations Regarding Birds

Impact Correlations	CODs preliminary results
SEABIRDS AND RESTING BIRDS	
Permanent loss of habitats due to displacement (avoidance)	The significance of avoidance behaviour and its follow-up effects depend on the overall availability of suitable areas. Avoidance behaviour is a species-specific topic.
Collisions (bird strike)	The actual number of bird collisions is not known. Those birds showing avoidance have a lower collision risk.
Barrier effects (e.g. fragmentation effects on the ecological habitat network, such as breeding or feeding areas)	Compared to migrating birds, sea birds and resting birds seem less endangered, as they may adapt to the wind farm facilities.

Impact Correlations	CODs preliminary results
MIGRATING BIRDS	
Collisions (bird strikes): Increased mortality due to collisions of birds with wind turbines.	Accurate numbers of collision victims are not known. They may vary between one and thousands of dead birds / year / turbine. However, some experts assume collisions risks were far lower than expected. However, migrating birds are exposed to a higher collision risk. There is a consensus that collisions are likely to be more frequent under bad weather and sight conditions (e.g. night-time flights).
Avoidance and barrier effect (disturbances at important stopover-sites): Increased consumption of energy reserves during migration due to avoidance reactions, possible loss or impairment of orientation.	The disturbance effect has not yet been quantifiable. Giving reason for deviation of flight routes and obstruction of potential resting areas, offshore wind farms of large extent diminish foraging and resting conditions, which may decrease reproduction rates. The effect of diminishing unaffected areas has to be seen in the context of the overall intense use.

In Denmark (Baltic Sea) and Germany (North Sea and Baltic Sea) comprehensive studies have been carried out which help to identify some "hot spots" of migration flight routes. Yet, localisation and delineation of bird migration routes is still a problem, because changing flight conditions (wind, visibility, day or night) lead to varying behaviour and routes.

Up to now, the effects of **habitat losses** and **barrier effects** are not measurable, predictions regarding migrating birds are uncertain. For sea-birds, approaches like a sensitivity index (see COD-D-27) would help to avoid most sensitive areas. Following the precautionary principle protected areas like Special Protection Areas (SPA) should generally be avoided.

Natural cumulative pressures (e.g. naturally poor breeding conditions) can aggravate the pressures caused by human activities. The assessment of cumulative effects on bird populations is thus highly required.

The **monitoring of collision risks** is still very essential. Approaches to quantify collision risks by modelling should be enforced. Research methods regarding collision victims should be improved (see COD-NL-002). Methods of how to gain information on the number and circumstances of bird collisions such as the development of camera systems for observation, accomplishment with a platform to facilitate the counting of collided birds and acoustic survey are still under discussion.

To provide a tool for predicting impacts that are currently uncertain still more knowledge gaps have to be closed. Models could assist to predicting the effects due to habitat loss and change (see COD-UK-37).

Cumulative effects on bird migration need to be discussed and addressed at the international level (e.g. a directive or regulation from the EC on the assessment of cumulative impacts, or a quota system, where each country can have a certain level of impact). But also the national authority is obliged to assess cumulative effects with regard to project applications. Thus, cumulative effects need to be discussed and addressed especially at the international level.

2.3 Benthos

The effects on benthos are investigated particularly in Danish monitoring studies. To a notable extent benthos communities are also part of the investigations in the baseline studies for project-related EISes in the German EEZ.

Table 4: Offshore Wind-related Impact Correlations Regarding Benthos

Impact Correlations	CODs preliminary results
Change of species composition / loss of (protected) species due to the introduction of artificial substrates.	According to Danish monitoring studies a change of species composition can be stated. Yet the significance of these changes is contended.
Long-term elimination of benthic communities or benthic species due to covering of the seabed by wind-turbine foundations.	Damaging biogenic reefs by scouring or smothering by scour protection is considered a serious risk, because of their conservation interest and low capacity for regeneration.
Change of habitat conditions by altered sedimentation and current.	It is assumed that the maximum total volume of sediment that could be released during construction is approximately one thousandth of the level of sediment habitually in motion across the site.
Change caused by the increase of sediment temperature in the area of electric cables.	Burying cables in the sea bottom would reduce a rise in temperature

The significance of the mentioned effects on benthos communities is discussed controversially. However, benthos communities are highly stressed by all ongoing activities leading to a loss or a change of habitat conditions (laying of cables, sediment extraction) and by fisheries.

If fisheries, esp. demersal trawling, were excluded from wind farm areas, this is expected to have significant positive effects on the abundance of benthos communities, as recurrent disturbance of habitats would cease.

2.4 Fish

The effects on fish are investigated in several Danish monitoring studies.

Table 5: Offshore Wind-related Impact Correlations Regarding Fish

Impact Correlations	CODs preliminary results
Introduction of new habitats (artificial hard substrate) causing a change the occurrence of fish stocks.	If fishery, esp. demersal trawling, is excluded from wind farm areas, this is expected to have significant positive effects on the abundance of fish stocks.
Electro-magnetic fields influencing the orientation.	Electromagnetic effects on fish stock are caused by cable routes. The prognosis of impacts due to electromagnetic fields is still not sufficiently operable, as the reach of effects, particularly behavioural changes like avoidance can neither reliably be predicted nor quantified.

Based on present knowledge, no significant negative impacts on fish by building and operating wind turbines have been stated. However, additional effects caused by offshore wind deployment of large extent might aggravate the situation. Presently, authorities often take decisions on applications without explicitly considering fish protection needs, as the concern is hardly operable in assessment procedures.

The closure of wind farm areas to fishery is supposed to have a positive effect on fish stocks. The increase of biomass (benthos communities) as a nutrient source for fish would support this effect.

2.5 Visual Landscape / Seascape

There are only few specific studies available concerning effects on visual landscape, some containing methodological approaches for the assessment of effects on visual landscape. The main relevant effects on visual landscape are described as

- change of specific or typical features or appearance of landscape by wind turbines,
- disturbance by intrusion of technical elements in natural environment,

- decrease of recreational qualities due to change of landscape appearance.

Effects on visual landscape play an important role in decision making if the intended site is located near to the coast or to islands. Members of the local population feel negatively affected by the change of a natural landscape to a landscape which is characterized by technical elements.
However, effects are evaluated differently dependent on the acceptance of wind energy use by the local population. Strategies to better inform the local population about the visibility of facilities might help to gain local acceptance. However, in some licensing procedures which ended up with a rejection the attitude of the public towards visual intrusion was possibly underestimated.
To gain acceptance information strategies should be improved. Participation of the local population in decision making processes should be enforced.
Effects of a potential decrease of recreational qualities have not been quantifiable up to now.

3 Mitigation Measures

Considering environmental requirements during site selection is the most effective way to avoid negative impacts. To stay away from sensitive areas or protection areas may diminish the technical measures which otherwise would have to be taken to reduce facility-related impacts.
The following list contains the most promising mitigation measures to reduce or eliminate impacts on the environment.

Table 6: Mitigation Measures

Mitigation / Avoidance	Measures
Reduction of visual intrusion	Keeping a large distance to the coast minimizes visual intrusion for the local population. In a distance of > 15 km visibility decreases significantly. Three rotor blades are perceived as least disturbing. Absorbing paint and compact, systematic placement of the poles also reduce visual impacts. Lowering visual intrusion can collide with safety interests. For safety reasons illumination during nighttimes is required. For illumination techniques should be used which minimize radiation to the sides.
Reduction of collision risks by (maneuverable) boats	Closure of the wind farm in a zone of 500 m around the wind farm minimizes the risk of boat collision. If boats are allowed to wind farm areas, a high visibility of the poles during day and night is necessary.
Reduction of collision risks of birds	Best avoidance can be achieved when taking bird prtection needs into account during site selection (e. g. avoiding migration corridors or routes).
Reduction of noise	Noise reduction during pile-driving requires technical innovation. Deterring sensitive species (,e.g. by pingers) is recommended. Scheduling construction work according to less sensitive phases of development should be compulsory. The timeframe for construction work depends on the affected species' main periods of foraging, resting and breeding. To ensure minimal impact on both fish and mammals pile driving should start gently to allow individuals to move away from the noise source.
Reduction of electromagnetic fields	Insulation of cables prevent the surrounding seabed from heating. Guidance on appropriate burial depths to minimize emission levels is needed.
Reduction of scour	Scour protection is essential to ensure the stability and safety of the facility. Conditions which would allow to renounce on scour protection and apply other measures to ensure stability must be checked thoroughly.

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